POLLUTION CONTROL DEVICE AND MAT FOR MOUNTING A POLLUTION CONTROL ELEMENT

Field of the Invention

The present invention relates to pollution control devices (e.g., catalytic converters, diesel particulate filters, etc.), to mats for mounting pollution control elements in such devices and, in particular, to catalytic converters used in exhaust gas purification devices and, more particularly, to a mat for mounting a catalyst support in a catalytic converter housing.

Background

Catalytic converters used in the exhaust gas purification devices of automobile and diesel engines normally contain a catalyst support composed of a monolith having a so-called "honeycomb structure" in which through holes are arranged in the shape of honeycombs, in a metal housing. This monolith is loaded with a catalyst such as a precious metal, and purifies exhaust gas by oxidizing carbon monoxide and hydrocarbons and reducing nitrogen oxides. This monolith catalyst support is formed from a metal or ceramic material. In order to receive the catalyst support in a metal housing, a mat for mounting the catalyst support (catalyst support mounting material) composed of alumina-silica-based fibers or other ceramic fibers is arranged between the metal housing and catalyst support, and the catalyst support is held and protected from damage.

However, the coefficient of thermal expansion of ceramic catalyst support is typically nearly a power of ten smaller than the coefficient of thermal expansion of the metal housing. Although catalytic converters are normally exposed to high temperatures of several hundred degrees, under such high temperatures, the thermal expansion of the metal housing exceeds the thermal expansion of the ceramic catalyst support due to the difference in the coefficients of thermal expansion between the metal housing and ceramic catalyst support. As a result, gaps expand between the metal housing and catalyst support resulting in a decrease in the holding strength of the catalyst support, leading to problems such as the occurrence of rattling in the catalyst support.

Therefore, it has been proposed to prevent a decrease of the holding strength of the catalyst support when gaps expand between the metal housing and catalyst support by

containing an expanding agent in the mat for mounting the catalyst support. See, for example, Japanese Unexamined Patent Publication No. 2002-514283 (page 2, pages 16-18). Namely, in this Patent Publication, a single sheet formed from a flexible expanding layer and a flexible expanding layer containing an expanding material is arranged between a metal housing and a catalyst support.

Summary of the Invention

In recent years however, due to the requirements for improved automobile fuel consumption and increasingly strict emissions controls, the catalytic devices used in automobiles are being exposed to even higher temperatures due to higher temperatures of the exhaust gas itself from the engine, and due to the use of a system in which exhaust gas is treated at as high a temperature as possible by locating the catalytic device immediately behind the engine in order to improve purification performance. For example, it is known to be not uncommon for the temperature of exhaust gas to exceed 1000°C under certain driving conditions in vehicles using a gasoline engine.

However, expanding materials such as the vermiculite, expanding graphite or expanding sodium silicate and so forth used in Japanese Unexamined Patent Publication No. 2002-514283 deteriorate when exposed to temperatures of 800-1000°C, and under a significant decrease in strength. In addition to the thermal deterioration, a mechanical shock such as decreases the holding strength of the catalyst support. In this Patent Publication, although the use of an expanding material is able to effectively accommodate changes in the gap between the metal housing and catalyst support, there is no discussion of the durability at high temperatures in excess of 800°C.

According to the present invention, a mat for mounting a pollution control element, like a catalyst support, can be provided that maintains support holding strength without impairing elasticity even when exposed to temperatures in excess of 800°C for long periods of time.

In order to solve one or more of the above problems, the present invention can provide a mat for mounting a pollution control element (e.g., a catalyst support, diesel particulate filter, etc.), and the pollution control device containing such a mat, where the mat comprises at least two layers, an alumina fiber layer and a ceramic fiber layer. These

layers can be provided in the form a single sheet without the use of an auxiliary bonding means.

Brief Description of the Drawings

Fig. 1 is an exploded perspective view of a catalytic purification device.

Fig. 2 is a cross-sectional view showing the constitution of a mat for mounting a catalyst support of the present invention.

Fig. 3 is a graph showing the changes over time in the bearing pressure of the mat for mounting a catalyst support of Sample 3.

Fig. 4 is a graph showing the extrapolated values of bearing pressure after 10 years of samples of Examples 1 and 2 and Comparative Example 1.

Detailed Description

The following provides an explanation of the present invention with reference to the drawings. Fig. 1 is an exploded perspective view of a typical catalytic converter. Catalytic converter 10 contains catalyst support 20, composed of a monolith having a so-called "honeycomb structure" in which through holes are arranged in the shape of honeycombs, in a metal housing 11. This monolith is loaded with a catalyst that purifies exhaust gas by oxidizing carbon dioxide and hydrocarbons and reducing nitrogen oxides. Catalyst support 20 is normally formed from a ceramic material, and is frequently extremely brittle. Consequently, a mat 3 for mounting a catalyst support is arranged between metal housing 11 and catalyst support 20 to protect catalyst support 20 from damage.

As shown in Fig. 2, mat 30 for mounting a catalyst support of the present invention contains at least two layers consisting of an alumina fiber layer 31 and a ceramic fiber layer 32, and these layers form a single sheet without the use of an auxiliary bonding means.

Alumina fiber layer 31 is formed from alumina fibers prepared by a precursor fibering process and ceramic fiber layer 32 is formed from ceramic fibers prepared by melting a mixture of alumina (Al_2O_3), silica (SiO_2) and other oxides followed by melt blowing or melt spanning. These fibers are formed from 80-95 wt% of fibers and 5-20 wt% of binder.

Here, in the present specification, the alumina fibers that compose alumina fiber layer 31 are crystalline fibers that contain 50 wt% or more, and preferably 70 wt% or more, of alumina. On the other hand, the ceramic fibers that compose ceramic fiber layer 32 are RCF (Refractory Ceramic Fiber) that contain 45 wt% or more of silica. Examples of other oxides besides alumina and silica include zirconia (ZrO_2), magnesia (MgO), calcia (CaO), chromium oxide (Cr_2O_3), yttrium oxide (Y_2O_3) and lanthanum oxide (La_2O_3).

The ceramic fibers that compose ceramic fiber layer 32 are preferably annealed. Annealing improved elasticity and improves the holding strength and durability of the mat. This annealing is carried out at a temperature of 700-1200°C, and preferably 950-1100°C, and the annealing time is preferably 0.5-2 hours.

Acrylic resin, styrene-butadiene, vinyl pyridine, acrylonitrile, vinyl chloride or polyurethane and so forth is used for the binder. In addition, an inorganic binder (e.g., glass particles, calcium carbonate, mica or magnesium hydroxide) or flexible thermosetting resin (e.g., unsaturated polyester, epoxy resin or polyvinyl ester) may also be contained in addition to the alumina fibers or ceramic fibers and binder.

The mat for mounting a catalyst support of the present invention is formed by forming a single sheet without the use of an auxiliary bonding means, such as by simultaneously forming a ceramic fiber layer on the upper surface of an alumina fiber layer. This "auxiliary bonding means" refers to an externally used adhesive means such as resin, adhesive, adhesive tape, stitches or staples.

Mats for mounting a catalyst support of the prior art that are composed of a multi-layered laminate were formed by first individually forming each layer followed by mutually adhering the layers using adhesive, adhesive film, stitches or staples. However, multi-layered mats in which the individual layers were adhered with adhesive or adhesive film may typically produce undesirable smoke or odor when used in a catalytic converter. In addition, this adhesive or adhesive film has an effect on the heat resistance of the mat. Moreover, the production costs of such a mat increase due to the cost of mutually adhering each layer as well as the cost of the adhesive or adhesive film used. On the other hand, in the case of mats in which the layers were adhered mechanically with stitches and so forth, the mechanical strength of the mat decreases at those sites where the stitches penetrate the mat, and there are problems with costs of the additional steps and materials required.

The present invention eliminates the above problems since a single sheet is formed from an alumina fiber layer and ceramic fiber layer without the use of such auxiliary bonding means.

More specifically, the mat for mounting a catalyst support of the present invention is formed by preparing a slurry containing alumina fibers and a slurry containing ceramic fibers (the solid portion of these slurries are preferably 5 wt% or less), adhering the first slurry to a screen or wire and so forth of a rolling machine, forming a lower layer by partially dehydrating this first slurry by gravity and/or vacuum, adhering the second slurry to the above partially dehydrated lower layer, forming an upper layer by similarly partially dehydrating, and then pressing using a pressing roller to increase the densities of both layers followed by drying completely with a heated roller. Although either the alumina fiber layer or ceramic fiber layer may be initially formed as the lower layer, it is preferable during drying that the thickest layer be the lower layer that is formed first.

In this manner, due to the step of adhering a second slurry onto a layer formed by partially dehydrating a first slurry followed by dehydration of the second slurry, the both components are partially mixed particularly at the interface between the two layers. As a result, the two layers are permanently and effectively adhered without the use of an auxiliary bonding means such as an adhesive, allowing the formation of an integrated sheet.

In the mat for mounting a catalyst support of the present invention, the weight ratio between the alumina fiber layer and the ceramic fiber layer is preferably 3:11-11:3. In addition to the two-layer structure composed of these alumina fiber and ceramic fiber layers, the mat for mounting a catalyst support of the present invention may employ a structure of three or more layers that include other layers composed of these materials or other materials. In this case, however, at least one of the outermost layers must be an alumina fiber layer.

As shown in Fig. 1, a catalytic purification device can be completed by wrapping the mat for mounting a catalyst support obtained in this manner around a catalyst support to that an alumina fiber layer is in contact with the catalyst support, and then containing it in a metal housing.

Examples

Example 1

92 wt% of alumina fibers, composed of 72 wt% of alumina and 28 wt% of silica, were mixed with 8 wt% of binder (acrylic latex, Nippon Zeon: Nippore LX-816) followed by the addition of water to prepare a first slurry. In addition, 92 wt% of silica fibers (Shinnikka Thermal Ceramics: SC-1260D1), formed by melting and composed of 46 wt% of alumina and 53 wt% of silica, were mixed with 8 wt% of the above binder followed by the addition of water to prepare a second slurry. Samples 1 through 5 of mats for mounting a catalyst support having the weighing capacity ratios between the alumina fiber layer and ceramic fiber layer shown in Table 1 were obtained by the above ordinary rolling method using these slurries.

Example 2

With the exception of using ceramic fibers that were annealed for 60 minutes at a temperature of 1000°C, samples 6 through 8 of mats for mounting a catalyst support shown in Table 2 were obtained in the same manner as Example 1.

Comparative Example 1

With the exception of forming the ceramic fiber layer from 41 wt% of vermiculite, 47 wt% of ceramic fibers and 12 wt% of binder, samples 9 through 13 of mats for mounting a catalyst support shown in Table 3 were obtained in the same manner as Example 1.

Evaluation Method

The high-temperature holding strength (bearing pressure) and durability of the samples were evaluated in the manner described below. Namely, each sample was cut to a diameter of 45 mm, and each cut sample was then clamped between two plates above and below of a compression tester so that the alumina fiber layer was on the high-temperature (900°C) side. The samples were compressed and the pressure was adjusted to 130 kPa after 5 minutes. Next, the two upper and lower plates were heated and the times when the plates reached 900°C and 700°C, respectively, were taken to be time 0. The changes in bearing pressure were then recorded every hour for 20 hours. The results for sample 3 are

shown in Fig. 3. The formula $Y=aX^b$ can be determined from this graph as an approximation of changes in bearing pressure. Bearing pressure extrapolated values were then determined using this approximation formula, and are shown in Tables 1 through 3.

Table 1

		1st layer Ceramic fibers (92%), binder (8%)	2nd layer Alumina fibers (92%), binder (8%)	Approx. formula for changes in bearing pressure	Bearing pressure extrapolated value after 10 years (kPa)
Sample 1	Weighing capacity (g/m2)	300	1100	$Y=85.933X^{-0.0566}$	45.1
	Weighing capacity ratio	3	11		
Sample 2	Weighing capacity (g/m2)	500	900	$Y=68.21X^{-0.0589}$	34.9
	Weighing capacity ratio	5	9		
Sample 3	Weighing capacity (g/m2)	700	700	$Y=65.13X^{-0.082}$	25.6
	Weighing capacity ratio	7	7		
Sample 4	Weighing capacity (g/m2)	900	500	$Y=48.132X^{-0.0724}$	21.1
	Weighing capacity ratio	9	5		
Sample 5	Weighing capacity (g/m2)	1100	300	$Y=43.803X^{-0.1343}$	9.5
	Weighing capacity ratio	11	3		

Table 2

		1st layer	2nd layer	Approx. formula for changes in bearing pressure	Bearing pressure extrapolated value after 10 years (kPa)
		Ceramic fibers (92%), binder (8%)	Alumina fibers (92%), binder (8%)		
Sample 6	Weighing capacity (g/m2)	300	1100	$Y=103.57X^{-0.0493}$	59.1
	Weighing capacity ratio	3	11		
Sample 7	Weighing capacity (g/m2)	700	700	$Y=94.206X^{-0.0446}$	55.5
	Weighing capacity ratio	7	7		
Sample 8	Weighing capacity (g/m2)	1100	300	$Y=90.317X^{-0.0538}$	49
	Weighing capacity ratio	7	7		

Table 3

		1st layer Vermiculite (41%), ceramic fibers (47%), binder (12%)	2nd layer Alumina fibers (92%), binder (8%)	Approx. formula for changes in bearing pressure	Bearing pressure extrapolated value after 10 years (kPa)
Sample 9	Weighing capacity (g/m2)	300	1100	$Y=150.42X^{-0.1143}$	41
	Weighing capacity ratio	3	11		
Sample 10	Weighing capacity (g/m2)	500	900	$Y=196.79X^{-0.1574}$	32.8
	Weighing capacity ratio	5	9		
Sample 11	Weighing capacity (g/m2)	700	700	$Y=234.08X^{-0.2256}$	18
	Weighing capacity ratio	7	7		
Sample 12	Weighing capacity (g/m2)	900	500	$Y=311.91X^{-0.2828}$	12.5
	Weighing capacity ratio	9	5		
Sample 13	Weighing capacity (g/m2)	1100	300	$Y=344.19X^{-0.4101}$	3.24
	Weighing capacity ratio	11	3		

A graph containing a plot of extrapolated bearing pressure values after ten years is shown in Fig. 4. As is clear from Fig. 4, the high-temperature holding strength after 10 years of the mat for mounting a catalyst support of the present invention is improved by about 40% over a mat containing an expanding agent of the prior art at alumina fiber layer to ceramic fiber layer ratios of 7:7-3:1. Moreover, when annealed ceramic fibers are used, high-temperature holding strength after 10 years was improved by about 4-5 times at an alumina fiber layer to ceramic fiber layer ratio of 3:11, and by about two times at an alumina fiber layer to ceramic fiber layer ratio of 7:7.

The mat for mounting a catalyst support of the present invention maintains support holding strength without impairing elasticity even if exposed to high temperatures in excess of 800°C for long periods of time.